Industrial Marketing Management xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Industrial Marketing Management

Defining and identifying disruptive innovations ☆

Delmer Nagy [a,*], Joseph Schuessler [a], Alan Dubinsky [b]

[a] Tarleton State University, United States
[b] Purdue University, United States

ARTICLE INFO

Article history:
Received 19 May 2015
Received in revised form 24 November 2015
Accepted 29 November 2015
Available online xxxx

Keywords:
Innovation
Technology adoption
Managerial decision making
Disruptive innovation

ABSTRACT

Three essential questions about innovations prevent academics from helping managers determine if a new technology is a disruptive innovation to their organization. First, what is a disruptive innovation? Second, how can a disruptive innovation be disruptive to some and yet sustaining to others? Third, how can disruptive innovations be identified before a disruption has occurred in an organization? This paper proposes answers to these three questions by redefining disruptive innovations through use of innovation adoption characteristics. Through the relative nature of innovation characteristics, a heuristic, or Baedeker, to better determine if an innovation could be disruptive to an organization is proposed. Illustration of the approach is presented to show how potentially disruptive innovations could be identified before an organizational disruption has occurred.

1. Defining and predicting disruptive innovations

How can managers determine if a technology will disrupt their organization? In the article "Disruptive Technologies: Catching the Wave," the authors (Bower & Christensen, 1995) described an idea that has long affected business sustainability: the notion that new technologies can create new markets or radically change, or disrupt, the status quo in existing markets. Although they were not the first to identify the creative destruction caused by new innovations, identification of new market and low-end innovations provided researchers constructs with which to examine effects of new innovations on marketplaces (Bower & Christensen, 1995). Characterizing innovation effects on marketplaces spawned a movement to enhance understanding and improve prediction of such technologies on marketplaces (Adner, 2002; Christensen, 2006; Christensen & Raynor, 2003; Danneels, 2004; Hang, Chen, & Yu, 2011; Schmidt & Druehl, 2008). The primary goal of this stream of research appears to be *prediction* of marketplace disruptions caused by new innovations.

Predicting disruptiveness of an innovation is important for market incumbents so that they avoid inimical consequences from ignoring a disruptive innovation. These adverse outcomes include reduced market share, decreased status, or even bankruptcy or death of an organization (Bower & Christensen, 1995). But how is an organizational manager to know if a given technology will result in a marketplace disruption or even affect their organization? A commonly held belief is that, if managers could identify disruptive innovations before these technologies have affected markets, managers could take actions to turn a potential marketplace disruption into a new opportunity—or at the very least, prevent the failure of their organization. Because the ability to predict disruptive innovations can have far-reaching effects, researchers have essayed to predict disruptions caused by new innovations. These studies, though, have at least three common problems: (1) the definition of a disruptive innovation is vague, as the definitions focus on market impacts; (2) how can disruptive innovations be disruptive to some, but not to all organizations; and (3) data generally are generated only after a disruption has taken place (Govindarajan & Kopalle, 2006; Hang et al., 2011; Myers, Sumpter, Walsh, & Kirchhoff, 2002; Paap & Katz, 2004; Schmidt & Druehl, 2008). The foregoing issues have put pressure on researchers to more clearly and accurately *define*, *or identify*, what a disruptive innovation is.

Because Christensen and Bower characterized marketplace disruptions, or the effects new technologies can have on existing marketplaces, an opportunity exists to define how new technologies facilitate these market changes. In other words, technology characteristics that can contribute to marketplace disruptions can be identified to extend disruptive innovation theory. Indeed, at least six articles have sought to identify or define disruptive innovations from an innovation perspective as opposed to a marketplace perspective (Adner, 2002; Christensen, 2006; Christensen & Raynor, 2003; Danneels, 2004; Hang et al., 2011; Schmidt & Druehl, 2008), yet the ensuing definitions fall short of identify specific innovation characteristics that conceivably could clarify the concept of a disruptive innovation. Unambiguously defining a disruptive innovation is essential for both academic and practical reasons. Academically, unequivocally defining a disruptive innovation is critical to address causal theory of reference (Kripke, 1977; Putnam, 1973). As philosophers of business, researchers assign meaning with terms in

☆ The authors gratefully acknowledge the editor and reviewers for their invaluable assistance and encouragement.

* Corresponding author.
E-mail addresses: Nagy@Tarleton.edu (D. Nagy), Schuessler@Tarleton.edu (J. Schuessler), dubinsky@purdue.edu (A. Dubinsky).

http://dx.doi.org/10.1016/j.indmarman.2015.11.017
0019-8501/

their fields; as experts in business, they provide references for "disruptive innovations," as the business discipline has proposed the term (Bower & Christensen, 1995). This academic ownership of terms is common. For example, the term "lion" is defined by the community of zoologists; the definition of an "elm tree" is defined by the community of botanists; and if academics of the business community seek ownership of the idea of the "disruptive innovation," they need to proffer a clear definition of what a disruptive innovation is. Otherwise, the term will likely not have a specific definition, thus possibly leading it to become merely another business buzzword.

From a pragmatic perspective, a refinement of the definition of a disruptive innovation is essential for managers. How can a business decision maker analyze a technology to predict whether a new technology has the potential to be disruptive to a marketplace or to their organization? After all, Christensen has identified the "disruptive to some, but not to all" effects of innovative technologies. Accordingly, might an innovation revolutionize a marketplace or an organization, thus having drastic changes or even contributing to the failure of the business? Will business professionals operate blindly in a rapidly changing technological environment?

Given the above-mentioned dialectic, this paper seeks to answer the following three essential questions surrounding disruptive innovations so as to provide managers a lens through which to view new innovations and answer the three longstanding questions about this typology of technology: (1) what is a disruptive innovation? (2) how can disruptive innovations be disruptive to some adopters and yet be incremental or sustaining to others? and (3) how can disruptive innovations be predicted before an organizational disruption has occurred? These questions will be answered by *shifting the focus* of the definition of a disruptive innovation. Existing disruptive innovation theory focuses on market characteristics, new market, and low end innovations. By using innovation adoption theory, three *innovation characteristics* are identified to ground disruptive innovations in a technology, not a marketplace—an innovation's (1) technical standard, (2) functionality, and (3) ownership (justification for undergirding the definition with these features will be subsequently offered). Then, through this redefinition, an examination of an innovation's characteristics, as compared to existing technologies used by an organization, can be used potentially to identify relative effects of an innovation on an organization. Finally, through use of the value chain, impact of a potentially disruptive innovation can be better understood vis-à-vis an organization: the innovation and its effects could be rated, going from its disrupting primary or secondary operations, to its sustaining primary or secondary operations, to its having no effect. This paper will first review germane literature to assist in defining what a disruptive innovation is. Second, an explanation about the relative effects of disruptive innovations is offered. Third, a method for potentially identifying disruptive innovations before the disruption occurs is proposed. Fourth, case that highlights how this method can be used with emerging technologies is proffered. The paper concludes with a discussion about the benefits of the redefinition, potential applications for practitioners, and future research areas.

2. Literature review

What is a disruptive innovation? Although identifying *effects* of a disruptive innovation on an organization or marketplace is relatively easy, creating a pellucid definition of a disruptive innovation has been elusive. Perhaps this is because Christensen identified two different types of disruptive innovations: new market innovations and low-end innovations. The effects of these two types of disruptive innovations on markets are different.

New market innovations act, as their name implies, by creating new demand for a new technology, resulting in consumers demanding this new product. Conversely, low-end innovations provide similar characteristics to existing technologies but cost substantially less. Compounding the effects of these two different types of innovations, Christensen has stated that despite some innovations' being disruptive to one group, the same innovations could be sustaining to another group (Adner, 2002; Christensen & Raynor, 2003; Christensen, Bohmer, & Kenagy, 2000a, 2000b; Danneels, 2004; Schmidt & Druehl, 2008). Although the literature agrees that disruptive innovations cause a market to behave differently, what about these disruptive innovations changes to marketplace behavior? In other words, which innovation *characteristics* cause marketplaces to disrupt? A definition for disruptive innovations that is grounded in innovation characteristics would provide insight into what innovation characteristics result in marketplace changes. Without a consistent definition, grounded in innovation characteristics, academics and practitioners alike are chasing phantoms: the ontology, or the nature of disruptive innovations, and epistemology, or knowledge surrounding disruptive innovations, are difficult to move forward without agreement as to what is being studied (Bryman & Bell, 2011; Guba & Lincoln, 1994).

Instead of having a *stipulated* definition, or a definition based on precisely defined concepts, academics and practitioners are left with an extracted definition, or a definition based on common usage of the word (Kripke, 1977; Putnam, 1973). Unfortunately, common usage of the word allows for contextual inference and potentially variegated meaning: in other words, a disruptive innovation may or may not be disruptive, depending on how the word is used.

A stipulated definition is a definition in which a term is given a specific meaning for the purposes of a given argument in a context. For a disruptive innovation, it should be grounded in an innovation's characteristics. This foundation is needed because the topic of discussion is the innovation itself, and the disruptive component of that innovation. Any definition of a disruptive innovation that does not address innovation characteristics would appear to be discussing something other than the innovation itself. Therefore, a definition for a disruptive innovation that is grounded in the innovation itself is needed to move this body of knowledge forward. The need for a stipulated definition has been recognized by other business scholars as a fundamental criticism surrounding disruptive innovations (Markides, 2006, Schmidt & Druehl, 2008). Accordingly, two different definitions of a disruptive innovation have been proposed (Adner, 2002; Danneels, 2004; Schmidt & Druehl, 2008; Thomond & Lettice, 2002).

One definition of a disruptive innovation focuses on the *functional quality* and *cost* of an innovation. This definition defines disruptive innovations as an innovation with "good enough" functionality that has a low cost (Christensen, Baumann, Ruggles, & Sadtler, 2006; Christensen, Bohmer, & Kenagy, 2000a; Christensen, Horn, & Johnson, 2008; Paap & Katz, 2004; Thomond & Lettice, 2002). Theoretically, the lower quality and lower priced innovation incrementally improves until eventually the innovation competes with market leading products, thus disrupting the market status quo (Bower & Christensen, 1995). Defining disruptive innovations as lower quality products that compete on price does not appear to be an appropriate innovation characteristic with which to define a typology of technology. Indeed, price changes reflect a variety of factors from organizational processes and materials, to marketplace conditions. "Good enough quality" is a function of comparing two or more innovations that complete a similar task. Price and perceived quality are not innate innovation characteristics; rather, price and perceived quality are redolent of business strategy decisions. Further, competition on price and quality is a commonly accepted *business* strategy—but neither price nor perceived quality are innate innovation characteristics—on which to ground a definition of a typology of technology (Besanko, Dranove, & Shanley, 2009). As such, this definition essentially focuses on business strategies regarding market entry and overlooks *specific* innovation characteristics. This is important because an innovation's characteristics that create changes in customer expectations could disrupt existing, or potentially create new, markets, not a price point or entry strategy.

The other definition of disruptive innovations focuses *not* on an innovation's cost or quality but on *market characteristics*. Danneels

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017

(2004), Markides (2006), and Tellis (2006) advocate that disruptive innovations change the performance metrics, or consumer expectations, of a market. This definition moves the discussion of what constitutes a disruptive innovation forward, as it shifts the focus from market strategy to alignment of an innovation's characteristics with market expectations. However, this definition does *not* identify innovation characteristics that could potentially disrupt marketplace preferences. Specifically, which innovation characteristic or characteristics could be disruptive to the marketplace? Additionally, this definition does not answer the relativity of disruptive innovations—or how an innovation can be disruptive to one group but sustaining to another group. Therefore, this definition of a disruptive innovation remains somewhat vague, as a specific innovation characteristic, or set of characteristics, is not identified; instead, the importance of marketplace alignment is recognized.

2.1. Identification of disruptive innovation characteristics

Neither of the foregoing existing definitions of disruptive innovations identifies a *specific* innovation characteristic that could be disruptive. Rather, both definitions focus on factors *external* to the innovation, specifically market factors—costs, quality, performance metrics, and/or customer expectations. These factors are *external* to an innovation in that they change. An innovation's characteristics are *intrinsic*, or *innate*, and based within the innovation itself. Cost is set by an owner, as well as by changes based on a variety of factors external to an innovation. Quality is perceived by a user, as well as changes relative to peer innovations external to an innovation. Customer expectations change over time relative to other innovations and are also external to an innovation. Rather than identifying specific innovation characteristics to extend disruptive innovation theory, these works extend Christensen's definition by describing the marketplace conditions that can lead to marketplace disruption. None of these factors is intrinsic or innate to an innovation. This paper, however, proposes that innovation adoption theories, specifically those theories addressing innovation characteristics, be can be used to identify specific innovation characteristics intrinsic to an innovation that can cause marketplace disruptions.

Three innovation characteristics have been identified in innovation adoption literature as having the potential to change markets: *radical functionality*, *discontinuous technical standards*, and an *innovation's ownership* (Thomond & Lettice, 2002). *Radical functionality* is recognized in innovation adoption literature through articles describing radical innovations, or innovations that provide a user the ability to undertake a new behavior or accomplish a new task that was impossible before the invention of the innovation (Abernathy & Utterback, 1978; Anderson & Tushman, 1990; Dahlin & Behrens, 2005). Radical innovations disrupt markets in Christensen's new market fashion by creating new markets. Discontinuous technical standards are also recognized as having the potential to change markets in innovation adoption literature (Dewar & Dutton, 1986). Discontinuous innovations, or innovations that utilize new materials or new processes in the creation of existing technologies, typically disrupt markets by using less costly materials or more efficient production processes in the creation of existing technologies. Discontinuous innovations disrupt markets as described by Christensen's low end innovation. Radical functionality, discontinuous technical standards, and an innovation's ownership can be found in one form or another in several innovation adoption theories (Attewell, 1992; Rogers, 1995; Swanson, 1994). Perhaps the exemplar innovation adoption theory is Innovation Diffusion Theory (IDT), which proposes that five innovation attributes affect innovation adoption (Rogers, 1995): relative advantage, compatibility, complexity, trialability, and observability. Relative advantage specifically identifies functionality of an innovation as influencing the adoption of a technology. The concept of relative advantage recognizes that innovation functionality is not absolute between technologies. As the name of the construct implies, functionality is relative between technologies and between users.

IDT constructs of compatibility and complexity are directly tied to the *technical standards* of an innovation. Compatible technologies have similar technical standards, while complex technologies have new technical standards that create a knowledge barrier for users (Attewell, 1992). Complexity forces adopters to overcome knowledge barriers to maximize the effectiveness of the new technology (Attewell, 1992). The final two IDT attributes, trialability, and observability, have links to marketplace awareness or distribution channels and are dependent on ownership of an innovation. Innovation owners determine how the innovation is presented within a marketplace in terms of trialability and observability (Rogers, 1995).

Functionality and technical standards are further refined in extensions and modifications of adoption theories in the areas of radical and discontinuous innovations. For example, ideas related to radical innovations have been explored in conjunction with firm organization (O'Connor & DeMartino, 2006), organizational strategy and structure (Ettlie, Bridges, & O'keefe, 1984), context (Germain, 1996), and organizational adoption (Dewar & Dutton, 1986).

This work has observed that both radical and discontinuous innovations—or innovations with new functionality or with new materials or production processes—dramatically alter or disrupt existing organizational structure, strategy, context, and use.

The third innovation characteristic that influences the disruptiveness of an innovation is the *ownership* of an innovation. Ownership of an innovation is an innate but abstract characteristic: it does not have a physical manifestation. Ownership of an innovation is substantially different from functionality and technical standards of an innovation in that it is not a physical characteristic of the innovation; one cannot touch ownership. However, the ownership model of an innovation has established effects on business, influencing factors both inside and outside of organizations. Inside an organization, ownership influences costs, employee motivation, and organizational performance (Huang, 1997). Outside an organization, ownership models affect resource utilization and development, forms of sales, and services associated with innovations (Stam, 2009). Moreover, ownership of ideas—through patents, copyrights, and trademarks—limit and control nearly every aspect of an innovation (Chon, 1993; Joyce & Patterson, 2003). From production to distribution to terms of use, ownership of an innovation dictates how an innovation is received in a marketplace (Merges & Reynolds, 2000).

Because ownership establishes market prices, innovation-related services, and other ways in which an innovation interacts with a marketplace, ownership has many marketplace effects on innovations. While prices, services offered, and other marketplace offerings affect how an innovation is received, they are a result of the owners' of an innovation decision. Alternative forms of ownership in established industries have disrupted the status quo of these industries by changing characteristics like price, or services surrounding the innovation. These changes have effects on marketplace expectations surrounding innovations (Johnson & Greening, 1999).

This phenomenon can be illustrated with open source software. This type of software is widely recognized as disrupting some segments of the software industry and doing so without a radically different functionality or discontinuous technical standards. Indeed, many open source programs perform similar tasks to proprietary software, as open source programs can run on existing computers, needing no new technical standard and providing the same functionality. The disrupting factor associated with open source software is the ownership of the software—such software has no single definitive owner (Crowston, Wei, Howison, & Wiggins, 2012). Rather, it is collectively owned by a group of volunteers which create, manage, support, and distribute the technologies (Lakhani & Von Hippel, 2003). Such diffused ownership does not raise questions about the functionality or technical standards of the technology. It does, however, create questions about the price, services, and responsibilities associated with the ownership of the software, which in turn affect marketplace expectations (Crowston et al., 2012).

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017

Functionality, technical standards, and ownership are also linked to existing disruptive innovation theory. Successful innovations with radical functionality are the "new market" innovations identified by Christensen. When innovations offer something radical that is well received in the marketplace, these innovations can create new demand. Existing industry incumbents do not provide the same functionality, and these innovations act as their namesake and create a new market. However, radical functionality alone is not enough to ensure that a new market will be created. Business history is littered with radical innovations that never succeeded in the marketplace (Dewar & Dutton, 1986; Maidique & Zirger, 1984). Low end disruptive innovations entail changes to technical standards or ownership. These innovations seek to lower costs through the use of new materials, new production processes, or ownership structures. Changes in technical standards, or the use of lower cost materials or production processes, were used to identify and label the phenomenon of low end disruptive innovations in the data storage market (Bower & Christensen, 1995). For instance, although the functionality of data storage did not change, information was stored in a digital format, an aspect of data storage–the overall capacity or amount stored, was substantially modified based on the materials and concomitant production processes, or the technical standard, of the innovation. Because these changes in data storage afforded enhanced store data storage, the cost per unit of data stored was drastically reduced, thereby meeting the criterion for being a low end innovation.

Because the foregoing three characteristics are innate to an innovation, the disruptiveness of an innovation on a marketplace will be relative to other innovations and marketplace needs. If an innovation is providing radical functionality, or something new to the marketplace, the opportunity exists for the innovation to be a new market innovation. If an innovation seeks to lower costs through new technical standards (materials or production processes) or through new forms of ownership, the potential for a low end innovation exists. However, because organizations both use innovations *and* create innovations, managers need to identify technologies that could potentially disrupt either the markets where the organization compete *or* the innovations used by their organizations. For example, the market for automobiles may or may not be disrupted by the emergence of electric automobiles. The functionality of the two types of automobiles are nearly identical–consumers do not need to relearn how to drive automobiles based on the method of propulsion. However, technical standards that comprise the materials and processes to create the automobile substantially change. And if marketplace preferences were to shift to a high demand for electric automobiles, automobile manufacturers that did not have the technical standards, or materials and production capabilities, to produce electric automobiles may well lose market share or fail. Therefore, business decision makers need a definition of disruptive innovations that identifies specific inherent innovation characteristics to understand both the nature of the potential marketplace disruption—new market or low end—as well as the organizational effects the innovation may have directly on the organization.

2.2. Refinement of the definition of a disruptive innovation

This paper proposes that these existing theoretically recognized constructs—functionality, technical standards, and ownership—can be combined with existing definitions of disruptive innovations to extend the existing definition of disruptive innovations. By refining Danneels, Markides, and Tellis' definition, a disruptive innovation is defined here as "an innovation that changes the performance metrics, or consumer expectations, of a market by providing radically new functionality, discontinuous technical standards, or new forms of ownership." This definition includes three theoretically-grounded innovation characteristics that can potentially disrupt existing industries or organizations. Moreover, this definition addresses two major problems with the existing definition of disruptive innovations. First, it identifies specific innovation characteristics that can be identified and compared. Second, it answers the question regarding why an innovation might be disruptive to some, but not to all, entities. The solution is that innovation alignment of functionality, technical standards, and ownership models with existing organizational and marketplace technologies is afforded. Third, this definition allows for innovations to be categorized as either new market innovations, those innovations with new functionality, or as low end innovations—those innovations with discontinuous technical standards (materials or production processes) or new forms of ownership. Furthermore, by grounding the definition of a disruptive innovation in functionality, technical standards, and ownership, the disruptive potential for an innovation can be estimated before a drastic marketplace or organizational change occurs. By supplying academics and practitioners with these three innovation characteristics academics can now investigate specific innovation qualities and practitioners can now compare new technology characteristics with old technology characteristics.

2.3. Innovation relativity

One of the major challenges to improving the definition of disruptive innovations has been the "disruptive to some, but sustaining to others" nature of innovations (Bower & Christensen, 1995). Addressing this query is challenging, as the statement implies that innovation effects are *relative* (i.e., innovation effects are sensitive to an organization's existing context and technologies an organization has used). Innovation adoption theories promulgate that innovation characteristics are relative to other innovations. Constructs from Innovation Adoption Theory (e.g., relative advantage, complexity, compatibility) are grounded in the relative nature of innovations (Abernathy & Utterback, 1978; Henderson & Clark, 1990; Rogers, 1995; Tushman & Anderson, 1986). For example, an innovation's relative advantage is an attribute that is superior vis-à-vis another innovation. Complexity is the degree of difficulty of using an innovation relative to another technology. Compatibility is the extent to which an innovation can work with another innovation (i.e., how the technical standard or knowledge needed to use an innovation is associated with another innovation).

An illustration of innovation relativity comes from the work of Nord and Tucker (1987). They identified innovation relativity in their book concerning a novel financial innovation, negotiable order of withdrawal (NOW) accounts. NOW accounts were identified as a radical innovation to some financial institutions but an incremental innovation to other organizations. The disruptiveness of the NOW account was based on a financial firm's existing organizational business practices and how these business practices were implemented (i.e., the relative functionality and technical standards of the NOW account).

Because innovation adoption theories recognize relative effects of an innovation, disruptive innovations can use these theoretical bases to explain the "disruptive to some, but sustaining to others" conundrum. By comparing a potentially disruptive innovation with an existing innovation used in an organization, researchers ideally should now be better able to explain why an innovation is disruptive to one group but sustaining to another. To do so, they merely compare functionalities, technical standards, or ownership across innovations. Therefore, a "sustaining innovation" would be an innovation that has functionality, technical standards, or ownership with which an organization is familiar; conversely, a potentially "disruptive innovation" would have functionality, technical standards, or ownership with which an organization is not familiar. The disruptiveness of an innovation—how an innovation may be sustaining to one group but disruptive to another—is now predicated on how familiar an organization is with existing functionalities, technical standards, or forms of ownership.

2.4. Prediction of disruptions to organizations

Because the changes caused by disruptive innovations can have adverse effects on organizations, researchers have proposed methods

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017

(models) to use in predicting these disruptions to organizations and the marketplace (Paap & Katz, 2004; Sood and Tellis, 2011). However, many of these models have been confirmatory in nature—confirming that a disruption has taken place on a marketplace level, but not providing insight as to whether or not an organization was disrupted by a specific innovation. Theoretically, a predictive model should be able to identify a potentially disruptive technology before a disruption has occurred. Practically, theory should be able to be refined to a specific organization so that an organization can determine whether or not an innovation will be disruptive to that organization. Research seeking to predict disruptive innovations has focused on marketplace disruptions and has taken two distinct paths: a focus on modeling diffusion patterns or an adoption of an evolutionary approach to technology.

By identifying market forces, relative market sizes, and ability of an innovation to create new markets, Linton (2002) developed a model to determine the disruptiveness of an innovation at a market level of analysis. He used a Bass formula contextualized around the foregoing three variables and was able to provide confirmatory evidence of marketplace disruptions owing to changes in technology. Schmidt and Druehl (2008) took a similar approach to identify disruptive innovations. Instead of using a Bass formula, though, their models focused on market diffusion curves of technologies; they were able to confirm marketplace disruptions caused by new technologies. Although able to confirm marketplace disruptions, these models were confirmatory in nature and did not *predict* the potential disruptiveness of an innovation for a specific organization. In other words, the above-mentioned efforts were useful for identifying changes to a marketplace, but whether they would help individual organizations predict whether or not a given innovation would be disruptive to an organization is uncertain.

The second path to identify disruptive innovations has led to a discussion of technological stages—the evolution of a technology. Paap and Katz (2004) proposed three different cases that can potentially change the dominant technology of an industry or market. The first case highlights how an established technology matures to become the dominant driver of an industry. The second case focuses on user needs and how a new technology may better meet user needs than an established technology. The third case stresses how environmental changes may create new drivers for technologies, thus causing technologies to evolve to meet environmental changes. Moreover, Myers et al. (2002) proposed similar evolutionary stages for disruptive innovations, as innovations go from proof of concept to widespread market adoption. Both sets of researchers posit that disruptive innovations evolve relative to other functionality, technical standards (materials or production processes), or customer expectations. As with the predictive models, however, this work focused on the marketplace and did not provide insight for individual organizations to predict whether or not an innovation would be disruptive to that organization.

2.5. Prediction of disruptive innovations specific to an organization

To help organizations identify potentially disruptive innovations, prediction of a disruptive innovation should examine innovation/organization fit. The innovation side of this alignment will be grounded in this definition of a disruptive innovation, in other words, understanding the functionality, technical standards, and ownership of an innovation.

Many different models could be used to determine the organizational side of this fit, as there are several different organizational models. For example, organizations can be examined through just about any function or activity—how human resources are organized, how capital is distributed, how information is processed, how bureaucratic the organization is, how the organization addresses customer service needs, etc. To ground the predictive process, an organizational model that captures one of the defined innovation traits (i.e., functionality, technical standard, or ownership) would be useful, as the organizational model would overlap with the definition of a disruptive innovation. The value chain provides such a model, as it examines an organization through organizational functions. Therefore, use of the value chain provides an overlapping area, the functionality of an innovation and the functional area where that innovation could be used within that organization. Because of this functional overlap, by combining innovation characteristics with the value chain, organizations should ideally be able to predict *where* inside an organization a specific innovation could potentially disrupt the organization (Porter & Millar, 1985). The value chain also classifies organizational activities into two areas, primary and secondary areas, which describe how organizational activities are linked. Primary activities are conceptualized as the main activities of what an organization does. These focus on the transformation of raw materials into finished goods that are sold to customers. Secondary activities are dimensions of support that all primary activities draw upon. Because the value chain provides these distinctions, use of the value chain in the determination of an organizational disruption can give an organization a general idea about the scope of the potential disruption. If the technology is only used in secondary activities, the scope of the disruption may be of lesser importance and may not need to be addressed in the immediate future. Conversely, if the innovation is used in primary activities, organizations may need to take immediate action in response to the innovation.

This paper proposes a three-step method for predicting how an innovation may disrupt an organization (Fig. 1). This method is dependent on managers' understanding both the *context of their own innovation* and the *context of a potentially disruptive innovation*. To determine if an innovation could be potentially disruptive to an organization, a manager needs to identify first a candidate technology. Then, for this candidate technology he/she should define the functionality, technical standards, and form of ownership of that technology. Second, the manager must discern *where* inside an organization's value chain the innovation is used. This requires that the organization understands the context of the organization and where within the organization the innovation could be used. Knowing the context surrounding the innovation should ascertain which value chain segment or segments would utilize the technology. Finally, understanding how the characteristics of the new technology, or the potentially disruptive technology, align relative to existing technologies used by the organization should provide some understanding about how potentially disruptive an innovation might be to the organization. Notwithstanding possible assumptions and inaccuracy, predicting how innovation characteristics align with marketplace needs to create a disruption, this three-step technique can provide managers a tool to potentially identify disruptive innovations before a disruption has occurred.

The first step in this process could be undertaken by comparing the functionality, technical standards, and forms of ownership of the innovation in question with the existing technology inside an organization's value chain segments. Because managers will have contextual insight into their own organization, and the primary and secondary activities of the organization, managers will ideally have contextual capacity to determine if one or more of an innovation's characteristics are different from existing technology used by the organization. If an innovation has one or more characteristics that differ from innovations currently used by the organization, then that innovation has the potential to be a disruptive innovation through that characteristic (i.e., functionality, technical standards, or ownership). If the disruption can be characterized as affecting primary or secondary activities in the value chain, the organizational scope of the disruptiveness can be assayed. Shown in Fig. 1 is the three-step process.

2.6. Illustration of the 3-step method

For this example, the method will focus on three-dimensional printing, or 3D, printers that layer or spray plastic in three dimensions. Most 3D printers currently focus on plastics, but future versions of 3D printers will use other materials; 3D printers that produce plastics are available and out of the prototyping stages of technology. 3D printers spray

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017

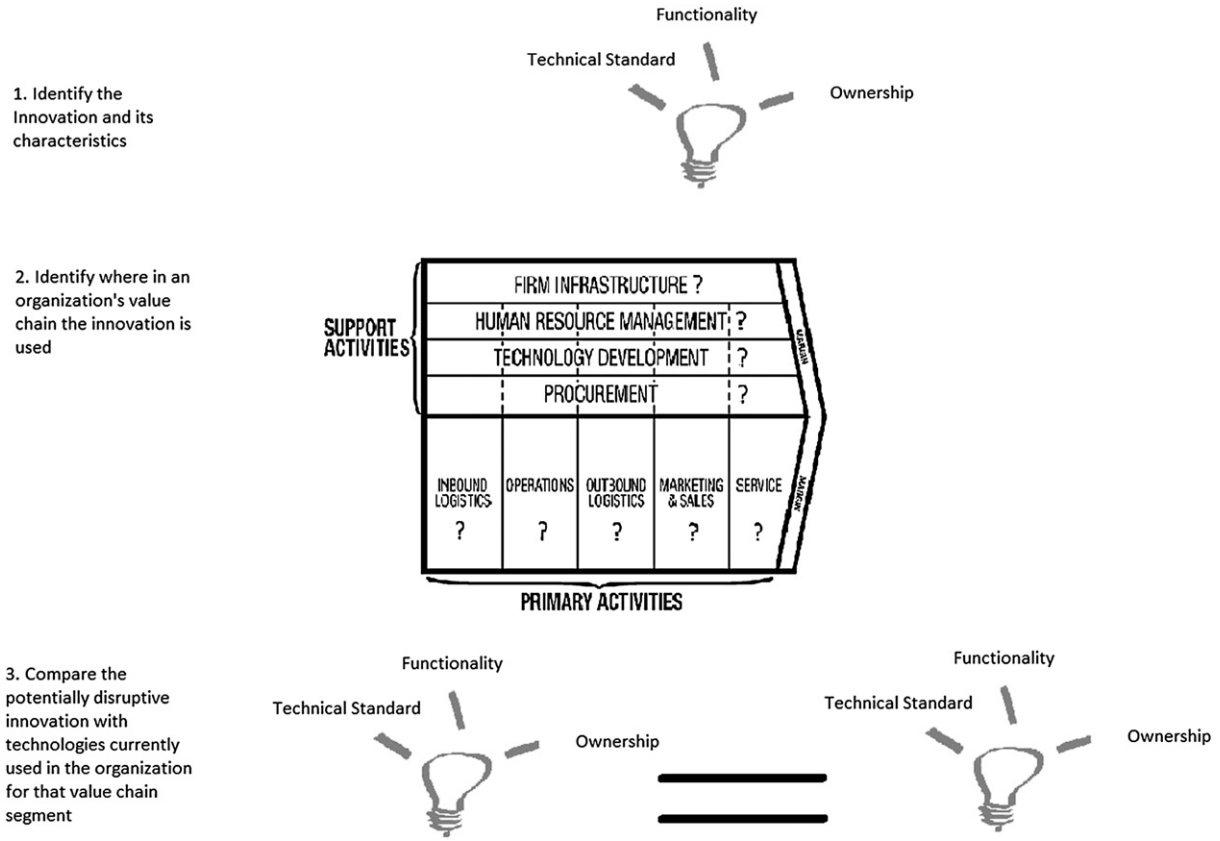

Fig. 1. Three steps to determine potential disruptive innovations.

plastic to produce a form. Forms can take a variety of shapes and are typically used to create first-time designs for manufacturers. Many industries, from architecture to medicine, use these forms (Giannatsis & Dedoussis, 2009; Utela, Storti, Anderson, & Ganter, 2008). Advances in 3D printing promise to move the technology beyond simple plastic forms, but these advanced printers are not widespread or mainstream as of yet (Giannatsis & Dedoussis, 2009; Utela et al., 2008).

Many trade magazines and technology leaders have identified 3D printing as a potentially disruptive innovation (Lipson & Kurman, 2013; Petrick & Simpson, 2013; Rayna & Striukova, 2014). This illustration uses two fictional organizations in the same extended value chain—one organization that produces plastics (a potential supplier) and another that sells plastics (a potential retailer), to demonstrate how these two different organizations could interpret 3D printers as having relative disruptive effects. Organization A is the plastics manufacturer; Organization B, the plastics retailer.

2.6.1. Step 1: identify the innovation and its characteristics

To examine the potential disruptiveness of 3D printing, the three-step process begins by identifying the functionality, technical standards, and forms of ownership of 3D printers.

- *Functionality*: The functionality of 3D printing is the production or manufacture of plastic goods. This is *not* new functionality, as injection molds have traditionally been used to create plastic products. Because the functionality is not new, 3D printing does not have the capacity of becoming a new market innovation for plastic manufacturers.
- *Technical standards*: 3D printers are large printers that layer or spray plastic into different forms. Traditionally, plastic products are created through injection molding or through extrusion. Both injection molds and extrusion use a different technical standard from that of a 3D printer. Layering or spraying plastic into forms is a *new technical standard* for an existing functionality. Because 3D printing offers a new technical standard, the technology has the opportunity to become a low end disruptive innovation.
- Ownership: 3D printers come in a variety of ownership options, though the most commonly sold printers are proprietary in nature. Ownership of 3D printers is complex, as there are three major components: hardware, software, and materials used by the printer. Each of these components may be proprietary or open source in nature. Typically, the hardware and printing materials are proprietary. Software is considerably different, though, as there are both open source and proprietary versions of 3D software. Proprietary software tends to be more likely to be used for commercial needs, as manufacturers of 3D printers produce all three components (hardware, software, and materials) that align or are compatible with one another.

2.6.2. Step 2: identify where in an organization's value chain the innovation is used

Organization A (the plastics manufacturer) and Organization B (the plastics retailer) will have different segments of the value chain affected by 3D printing, thus resulting in relative effects of the technology. Organization A will most likely consider functionality of 3D printers. This functionality is the production of plastic products, the primary operations for Organization A. Because Organization A's operations focus on production of plastic products, Organization A seemingly would characterize 3D printers as having "primary effects" in the value chain. Specifically, the effects of 3D printing for Organization A would be the primary effects vis-à-vis operations.

Organization B will also likely vet the functionality of 3D printers. Because the functionality does not change (i.e., 3D printers are still producing plastic products), Organization B will have a difficult time in identifying value chain primary or secondary effects of 3D printers.

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017

After all, Organization B focuses on selling, not producing, plastic products. Although 3D printing may alter the production of plastic products, it putatively would not affect the retailing of these products. Consequently, 3D printing is said to have neither primary nor secondary effects on Organization B. Management, nevertheless, of Organization B may identify 3D printing as an opportunity to become vertically integrated in the value chain of its organization and regard this as an opportunity not only to sell plastic goods, but also to manufacture plastic components. Palpably, this is a decidedly different scenario for Organization B, one where the business model of the organization is changing.

2.6.3. Step 3: compare the potentially disruptive innovation with technologies currently used in the organization for that value chain segment

Organization A will regard 3D printing differently from Organization B. After all, 3D printing has primary operations effects on Organization A, but has at best only a negligible effect on Organization B. Given the foregoing circumstances, Organization A continues the analysis of 3D printing by comparing the existing technologies in its primary operations; Organization B, though, utterly stops further investigation.

To compare 3D printing with existing technologies, Organization A identifies what is currently being used for plastics production. Rather than using 3D printing, Organization A employs injection molding to create plastics. Injection molding is the current technical standard for the plastics industry. So, because 3D printers have no new functionality, both technologies—3D printing and injection molding—produce plastic parts. 3D molding, nevertheless, has a new technical standard: use of a printer as opposed to the use of an injection mold. The analysis continues as Organization A examines critical success factors for manufacturing operations. For Organization A, ability to create large volumes of standardized products, as well as ability to change production sets to meet production agility, is imperative.

Currently, 3D printing focuses on low volume production with the ability to quickly change production sets. This technology will disrupt a segment of the plastics manufacturing industry by shifting the technical standard of production for plastic components where low production runs of varying products is the critical success factor. Because Organization A focuses on large batches of standardized plastic products, 3D printing does not appear to be a significantly disruptive technology. However, organizations that focus on low production volume with rapidly changing production sets would appear to need to embrace this new technical standard or face disruptive industry forces.

3. Discussion

This paper contributes academically and practically to the ongoing discussion of disruptive innovations. Academically, two contributions are made. First, by redefining disruptive innovations with innovation characteristics of functionality, technical standards, and ownership, an extended definition for disruptive innovations is proposed: “an innovation with radical functionality, discontinuous technical standards, and/or new forms of ownership that redefine marketplace expectations.”

The second academic contribution provides insight into a longstanding question associated with disruptive innovations: how can an innovation be disruptive to some adopters but not to others? By redefining disruptive innovations to have specific characteristics, these characteristics can be compared with technologies currently used by an organization. If disruptive innovations have characteristics that are already used by an organization—be it functionality, a technical standard, or a form of ownership—then the innovation will not likely be disruptive to the organization. However if the functionality, technical standards, or form of ownership is not utilized by the organization, the innovation has potential to be disruptive to the organization.

Pragmatically, the redefinition of disruptive innovations leads to potential identification of disruptive technologies before a disruption to an organization has taken place. By using the preceding refined proposed definition in conjunction with their value chain, practitioners should be able to improve estimation of effects of potentially disruptive innovations. Simply following the three-step method outlined in this paper could facilitate prediction of disruptive innovations.

Although this paper moves the discussion of disruptive innovations forward, it also creates future research opportunities. The current methodology for potentially identifying disruptive innovations needs further refinement. After all, its assessment inside an organization's value chain, an innovation's characteristics, and marketplace alignment is not quantitatively based. Subsequent research should be conducted to quantify these areas.

Work has already been done to measure radical functionality of innovations (Dahlin & Behrens, 2005; Green, Gavin, and Aiman-Smith, 1995. Given the refined definition of disruptive innovations created here, radical functionality of new innovations should be measured from two points. First, the overall radicalness of an innovation's function relative to existing marketplace offerings needs to be measured. Second, potential disruptiveness would be the radicalness of a new innovation's functionality with an organization's current technical offerings. These two measures would need to be reconciled to assess the overall functional radicalness of a given innovation.

Similarly, measuring technical standards and ownership is needed to quantitatively assess disruptive innovations. Technical standards and ownership would also need to be measured from both an organization's and the marketplace perspective. Measurements from both orientations would need to be reconciled for an assessment to work.

In addition to the foregoing issues surrounding innovation characteristics of functionality, technical standards, and ownership, the methodology proposed here should be further examined. Perhaps there are technologies and situations that confirm this three-step method; peradventure, however, contexts may exist where the three-step approach does not apply. Cases applying this methodology would contribute to the prediction of disruptive innovations and allow for further refinements in predicting disruptive innovations. Investigation into disruptive innovations will surely continue, as new technologies emerge. Emerging fields—nano-technology, gene therapy, new forms of energy—will become increasingly important to understand how these technologies can potentially impact organizations.

References

Abernathy, W. J., & James, M. U. (1978). Patterns of industrial innovation. *Technology review*, *64*, 254–228.
Adner, R. (2002). When are technologies disruptive? A demand-based view of the emergence of competition. *Strategic Management Journal*, *23*(8), 667–688.
Anderson, P., & Tushman, M. L. (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. *Administrative Science Quarterly*, 604–633.
Attewell, P. (1992). Technology diffusion and organizational learning: The case of business computing. *Organization Science*, *3*(1), 1–19.
Besanko, D., Dranove, D., Shanley, M., & Schaefer, S. (2009). *Economics of Strategy*. John Wiley & Sons.
Bower, J. L., & Christensen, C. M. (1995). Disruptive technologies: Catching the wave. *Harvard Business Review video*.
Bryman, A., & Bell, E. (2011). *Business research methods 3e*. Oxford University Press.
Chon, M. (1993). Postmodern progress: Reconsidering the copyright and patent power. *DePaul Law Review*, *43*, 97.
Christensen, C. M. (2006). The ongoing process of building a theory of disruption. *Journal of Product Innovation Management*, *23*(1), 39–55.
Christensen, C. M., Baumann, H., Ruggles, R., & Sadtler, T. M. (2006). Disruptive innovation for social change. *Harvard Business Review*, *84*(12), 94.
Christensen, C. M., Bohmer, R., & Kenagy, J. (2000a). Will disruptive innovations cure health care? *Harvard Business Review*, *78*(5), 102–112 (Crowston).
Christensen, C. M., Horn, M. B., & Johnson, C. W. (2008). *Disrupting class. How disruptive innovation will change the way the world learns*. Mc Grow Hill.
Christensen, C., & Raynor, M. (2003). *The innovator's solution*. Boston: Harvard Business School Press.
Christensen, C. M., Bohmer, R., & Kenagy, J. (2000b). Will disruptive innovations cure health care? *Harvard Business Review*, 102–117 (September–October).
Crowston, K., Wei, K., Howison, J., & Wiggins, A. (2012). Free/libre open-source software development: What we know and what we do not know. *ACM Computing Surveys (CSUR)*, *44*(2), 7.
Dahlin, K. B., & Behrens, D. M. (2005). When is an invention really radical?: Defining and measuring technological radicalness. *Research Policy*, *34*(5), 717–737.

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017

Danneels, E. (2004). Disruptive technology reconsidered: A critique and research agenda. *Journal of Product Innovation Management*, *21*(4), 246–258.

Dewar, R. D., & Dutton, J. E. (1986). The adoption of radical and incremental innovations: An empirical analysis. *Management Science*, *32*(11), 1422–1433.

Ettlie, J. E., Bridges, W. P., & O'keefe, R. D. (1984). Organization strategy and structural differences for radical versus incremental innovation. *Management Science*, *30*(6), 682–695.

Germain, R. (1996). The role of context and structure in radical and incremental logistics innovation adoption. *Journal of Business Research*, *35*(2), 117–127.

Giannatsis, J., & Dedoussis, V. (2009). Additive fabrication technologies applied to medicine and health care: A review. *International Journal of Advanced Manufacturing Technology*, *40*(1–2), 116–127.

Govindarajan, V., & Kopalle, P. K. (2006). The usefulness of measuring disruptiveness of innovations ex post in making ex ante predictions*. *Journal of Product Innovation Management*, *23*(1), 12–18.

Green, S. G., Gavin, M. B., & Aiman-Smith, L. (1995). Assessing a multidimensional measure of radical technological innovation. *Engineering Management, IEEE Transactions on*, *42*(3), 203–214.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of Qualitative Research*, *2*. (pp. 163–194).

Hang, C. C., Chen, J., & Yu, D. (2011). An assessment framework for disruptive innovation. *Foresight*, *13*(5), 4–13.

Henderson, R. M., & Clark, K. B. (1990). Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, 9–30.

Huang, T. C. (1997). The effect of participative management on organizational performance: The case of Taiwan. *International Journal of Human Resource Management*, *8*(5), 677–689.

Johnson, R. A., & Greening, D. W. (1999). The effects of corporate governance and institutional ownership types on corporate social performance. *The Academy of Management Journal*, *42*(5), 564–576.

Joyce, C., & Patterson, L. (2003). Copyright in 1791: An essay concerning the founders' view of the copyright power granted to Congress in Article I, Section 8, Clause 8 of the US Constitution. *Emory Law Journal*, *52*(909).

Kripke, S. (1977). Speaker's reference and semantic reference1. *Midwest studies in philosophy*, *2*(1), 255–276.

Lakhani, K. R., & Von Hippel, E. (2003). How open source software works: "Free" user-to-user assistance. *Research Policy*, *32*(6), 923–943.

Linton, J. D. (2002). Forecasting the market diffusion of disruptive and discontinuous innovation. *Engineering Management, IEEE Transactions on*, *49*(4), 365–374.

Lipson, H., & Kurman, M. (2013). *Fabricated: The new world of 3D printing*. John Wiley & Sons.

Maidique, M. A., & Zirger, B. J. (1984). A study of success and failure in product innovation: The case of the US electronics industry. *Engineering Management, IEEE Transactions on*(4), 192–203.

Markides, C. (2006). Disruptive innovation: In need of better theory*. *Journal of Product Innovation Management*, *23*(1), 19–25.

Merges, R. P., & Reynolds, G. H. (2000). Proper scope of the copyright and patent power. *The Harvard Journal on Legislation*, *37*, 45.

Myers, D. R., Sumpter, C. W., Walsh, S. T., & Kirchhoff, B. A. (2002). Guest editorial a practitioner's view: Evolutionary stages of disruptive technologies. *Engineering Management, IEEE Transactions on*, *49*(4), 322–329.

Nord, W. R., & Tucker, S. (1987). *Implementing routine and radical innovations*. Lexington, MA: Lexington Books.

O'Connor, G. C., & DeMartino, R. (2006). Organizing for radical innovation: an exploratory study of the structural aspects of RI management systems in large established firms. *Journal of Product Innovation Management*, *23*(6), 475–497.

Paap, J., & Katz, R. (2004). Anticipating disruptive innovation. *Research-Technology Management*, *47*(5), 13–22.

Petrick, I. J., & Simpson, T. W. (2013). 3D printing disrupts manufacturing. *Research-Technology Management*, *56*(6), 12–16.

Porter, M. E., & Millar, V. E. (1985). *How information gives you competitive advantage.*

Putnam, H. (1973). Explanation and reference. *Conceptual change* (pp. 199–221). Netherlands: Springer.

Rayna, T., & Striukova, L. (2014). The impact of 3D printing technologies on business model innovation. *Digital Enterprise Design & Management* (pp. 119–132). Springer International Publishing.

Rogers, E. M. (1995). *Diffusion of innovations*. New York: The Free Press.

Schmidt, G. M., & Druehl, C. T. (2008). When is a disruptive innovation disruptive?*. *Journal of Product Innovation Management*, *25*(4), 347–369.

Sood, A., & Tellis, G. J. (2011). Demystifying disruption: A new model for understanding and predicting disruptive technologies. *Marketing Science*, *30*(2), 339–354.

Stam, W. (2009). When does community participation enhance the performance of open source software companies? *Research Policy*, *38*(8), 1288–1299.

Swanson, E. B. (1994). Information systems innovation among organizations. *Management Science*, *40*(9), 1069–1092.

Tellis, G. J. (2006). Disruptive technology or visionary leadership?*. *Journal of Product Innovation Management*, *23*(1), 34–38.

Thomond, P., & Lettice, F. (2002, July). Disruptive innovation explored. *Cranfield University, Cranfield, England. Presented at: 9th IPSE International Conference on Concurrent Engineering: Research and Applications (CE2002)*.

Tushman, M. L., & Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative science quarterly*, 439–465.

Utela, B., Storti, D., Anderson, R., & Ganter, M. (2008). A review of process development steps for new material systems in three dimensional printing (3DP). *Journal of Manufacturing Processes*, *10*(2), 96–104.

Please cite this article as: Nagy, D., et al., Defining and identifying disruptive innovations, *Industrial Marketing Management* (2016), http://dx.doi.org/10.1016/j.indmarman.2015.11.017